22 al 25 de septiembre de 2015

Biotechnologies are pushing sustainable palm oil production

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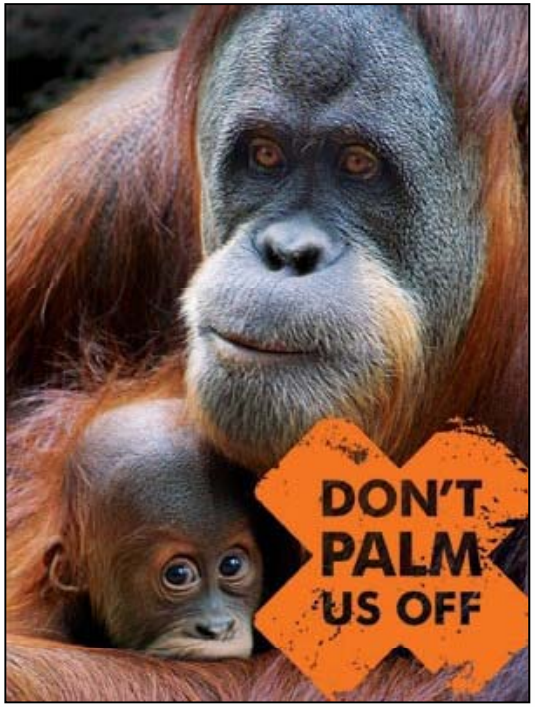
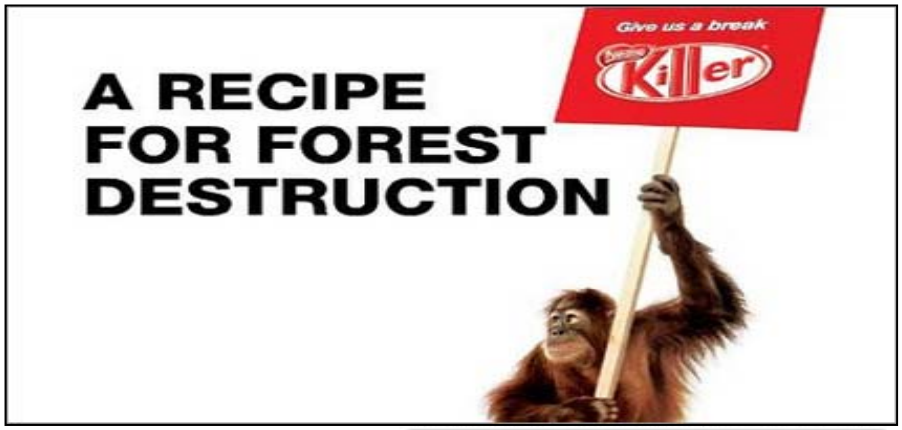
18th International Oil Palm Conference

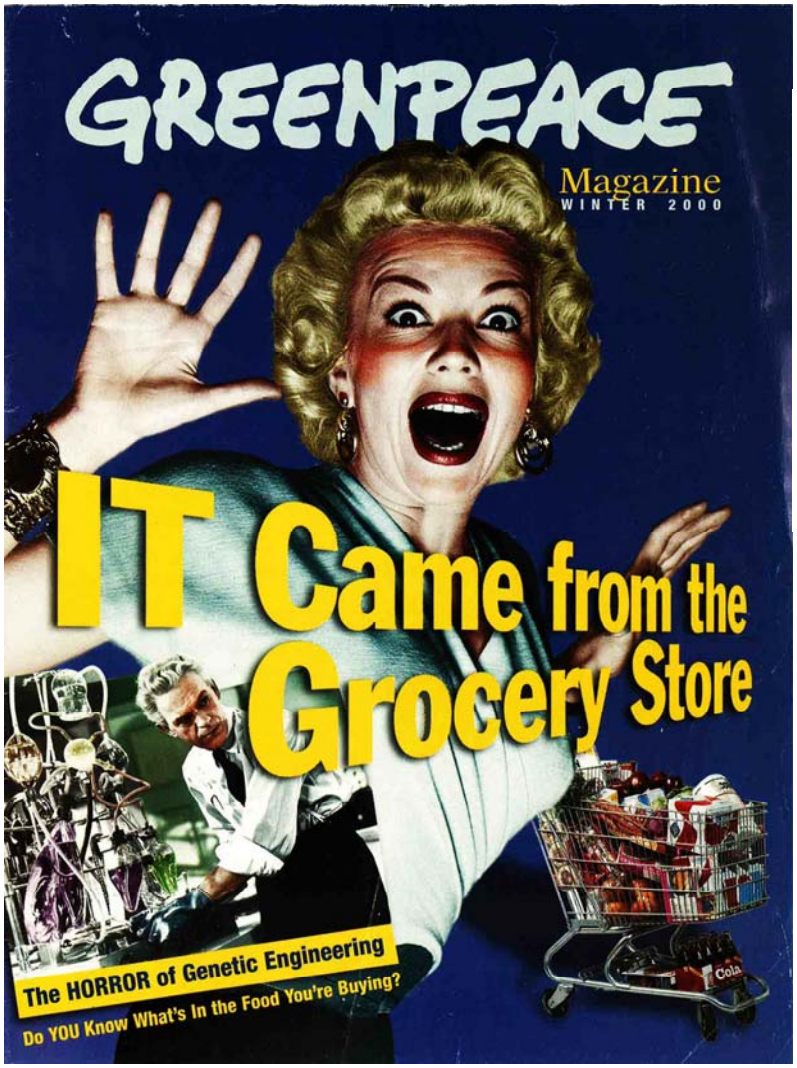
Dedicado a la memoria de Mauricio Herrera, con toda mi amistad y mi profundo respeto.

Oil palm sustainability is in the public debate

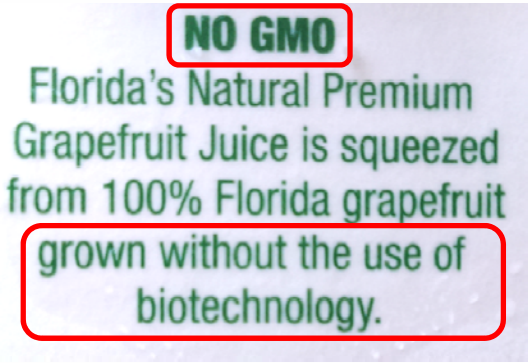




Biotechnologies <u>also</u> are in the public debate



Biotechnologies are not restricted to GMOs



Biotechnologies are working for sustainability

Simple Biotechnology facts

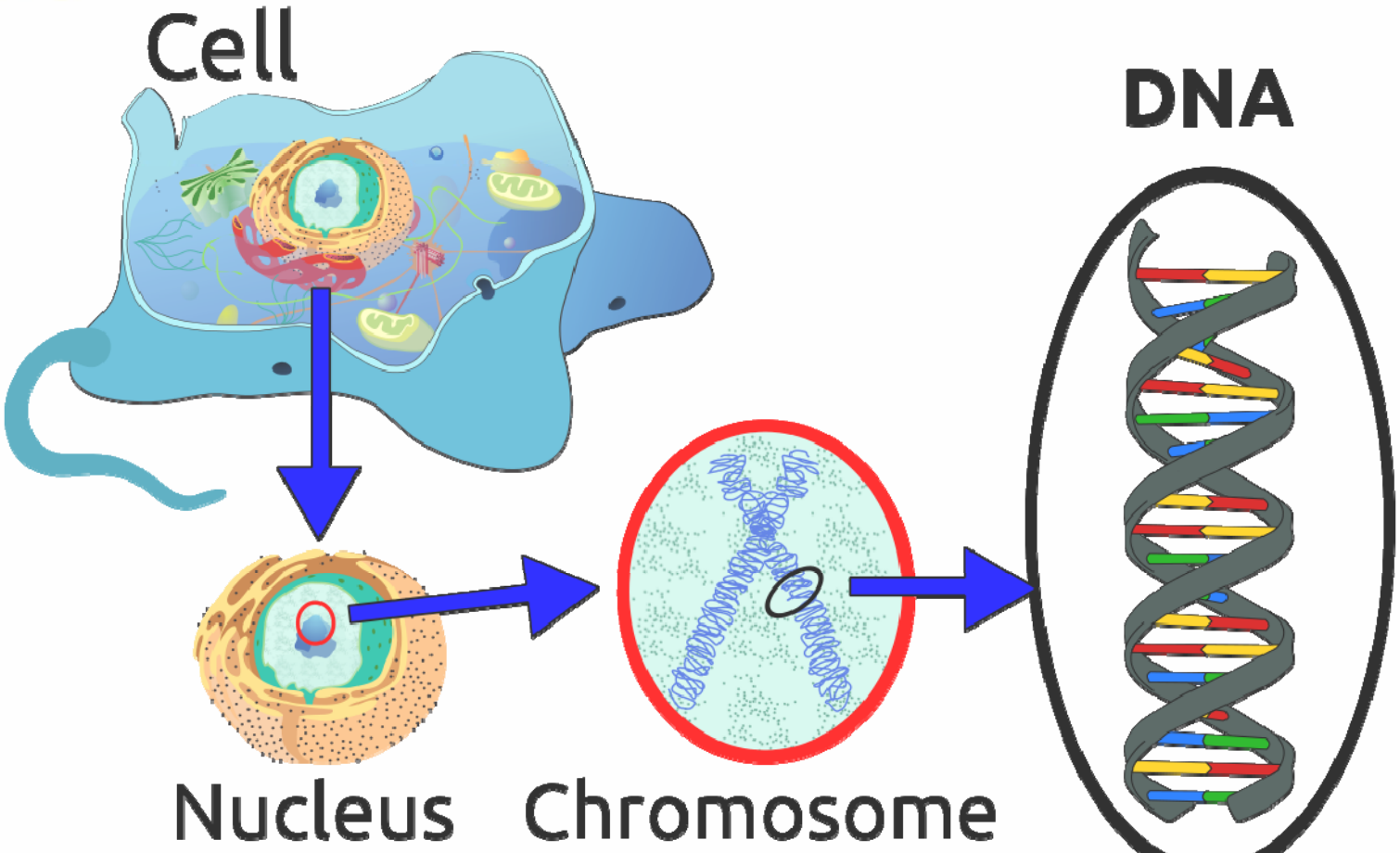
- Biotechnology is the **use of living systems and organisms to develop or make useful products**
- It uses the **controlled and deliberate manipulation of biological systems** for the efficient manufacture or processing of **useful products**
- For thousands of years, humankind has used biotechnology in **agriculture, food production and medicine**
- The fabrication of **wine, bread, beer, cheese, traditional medicine, the breeding of plants and animals** are very ancient biotechnologies







Genotype is what is in the DNA



The Cell Factory

DNA

Storage and transmission of genetic information

THE GENOME

Messenger RNAs

Synthesis
Changes
Degradation

PROTEINS

Structural
Regulatory
Enzymatic

THE TRANSCRIPTOME

Protein/DNA
Protein RNA
Interactions

Synthesis
Modifications
Degradation

LIPIDS

Structural
Energy storage

THE PROTEOME

GLUCIDS

Structural
Energy storage

The oil palm biotechnologies cloud

biotechnologists spectroscopy assembling antagonists
silico
challenges transcriptome technologies metabolism
databases transcript bioinformatics nitrogen Mb
environment data analysis ionomic sequence selection
WGS increasing scaffold sequencing loci zygotic
GMOs consortia sequence likely QTLs
MADS-box NGS resources resistance
efficiency palm breeding regulation
mutants gene epigenetic
EST yield biology Solexa
tolerance
ionomics sequences biotechnology individual
ACGT science rice genetic oil ionome Genomics environmental
reads RNA DNA yield complex
bioplastics Bhd information
Microarray consortium genome drought libraries
map productivity
metabolome traits
genomics expression data intensification physiology
Sanger soils crop systems Arabidopsis functions cDNA
somaclonal changes molecular breeding fertilizers Biosciences
genotype gene discovery variation contigs Biotechnologies
mantled sustainability metagenomics networks

WordItOut

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A sustainable palm oil production

- Poverty alleviation
- People's rights
- Workers' rights
- Land grabbing
- Public policies
- Ethical investments
- Public/private Partnership

- Agroecology
- Breeding
- Waste management
- Precision Agriculture
- Best agricultural practices
- GreenHouse Gas mitigation
- Integrated Pest Management
- Environmental services

ECOLOGICAL INTENSIFICATION

- Agroecology
- Breeding
- Waste management
- Precision Agriculture
- Best agricultural practices
- GreenHouse Gas mitigation
- Integrated Pest Management
- Environmental services

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Biotechnologies are tools for sustainability

- Agroecology
- Environmental services
- Breeding
- Waste management
- Precision agriculture
- Best agricultural practices
- Greenhouse Gases mitigation
- Integrated Pest Management

Biotechnologies are working for sustainability

GCTTCACACATT
GCTTCACACATT
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DNA barcoding
www.barcodinglife.org

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Characterizing biodiversity

- DNA barcoding: sequence one or a few 'standard' short stretches (c600bps) of DNA
  - individuals of a species should be more similar in DNA sequence, than they are to individuals of other species
- Establish database with link to names, specimens and other information
  - Take some tissue, sequence it, find out what it is, and what is known about it
  - Ultimately could be done with handheld DNA sequencers
- Provide a mechanism for speeding up the process of characterising biodiversity
  - Identification of unknown specimens to known species
  - Assist in the discovery of new species

DNA BARCODING

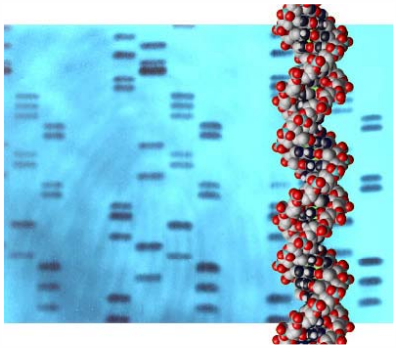
Biotechnologies are working for sustainability

- Agroecology
- Environmental services
- Integrated Pest Management
- Breeding
  - **Marker Assisted Breeding**
  - **Micropropagation**
  - **Gene discovery**
- Waste management
- Precision agriculture
- Best agricultural practices
- Greenhouse Gases mitigation

Biotechnologies at work: Molecular breeding

Certifying the origin and traceability of planting material

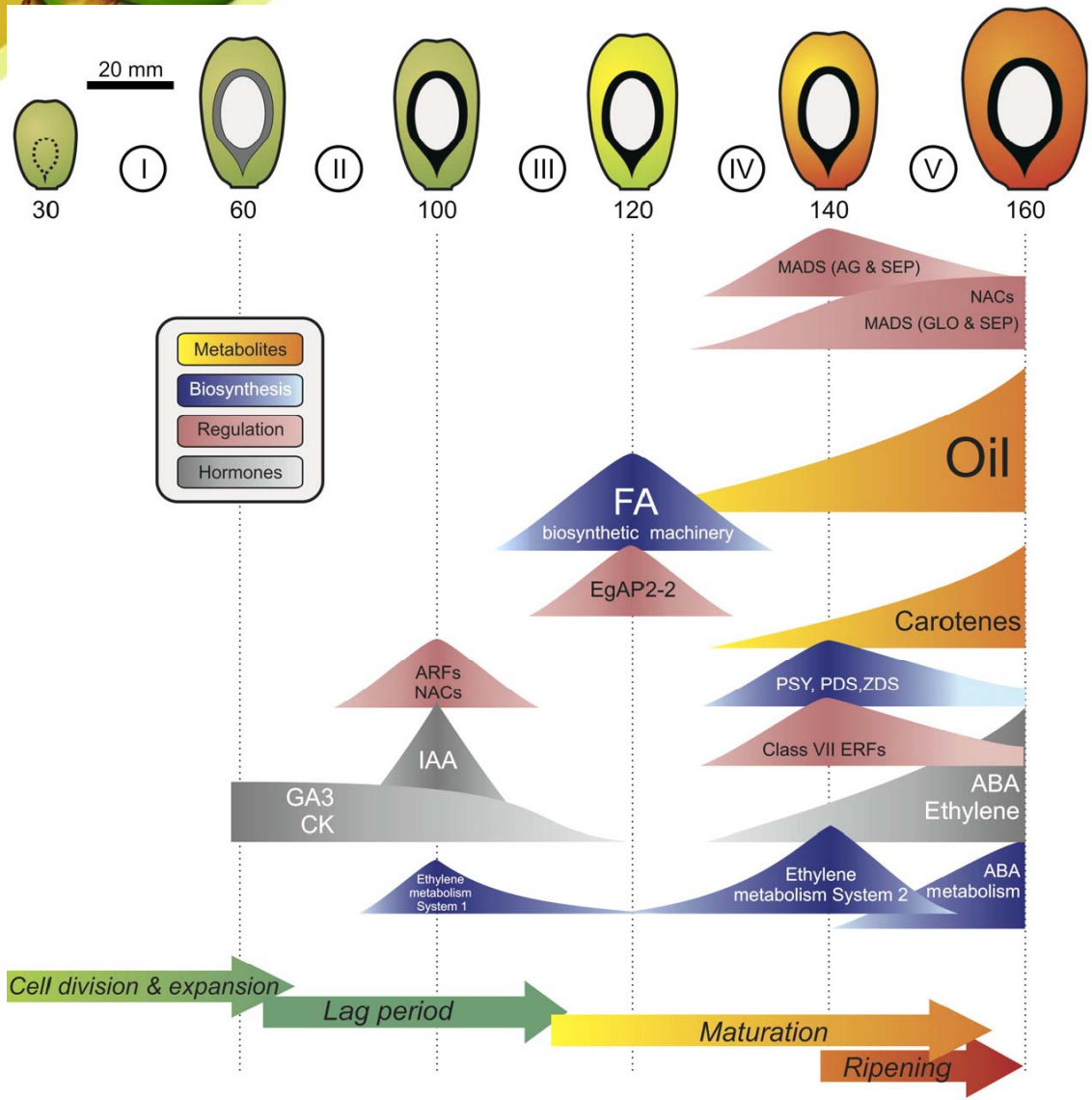
- Optimized management of genetic resources (core collections)
- Certification of pedigrees in genetic trials and seed gardens
- Certification of *tenera* trait in seeds



Improving the selection efficiency in *E. guineensis*

- Fine-tuning of the selection of genitors
- Agronomical traits QTL identified, MAB under way
- Resistances to pathogens (*Fusarium* wilt)

Biotechnologies at work: Gene discovery

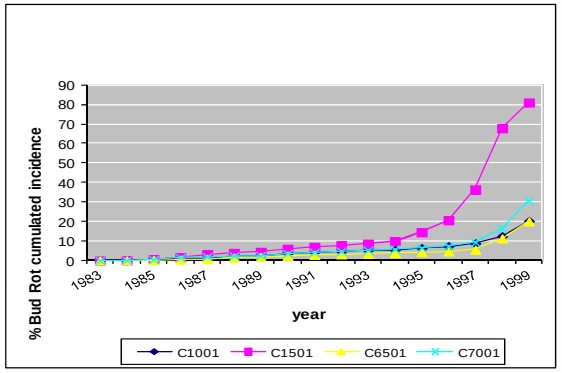


The time course of gene expression during oil palm fruit development

Biotechnologies at work: Clonal micropropagation

Elaeis guineensis

Identifying sources of tolerance to PC



Cloning of tolerant individual palms

Clonal planting material

BackCross (*E.g x E.o*) x *E.g*

Combining genes of interest originating from E. oleifera and E. guineensis

Cloning BC palms

Clonal planting material

Detecting genes for tolerance/resistance to PC

Cloning BC1 palms

Field trials in PC infested zones

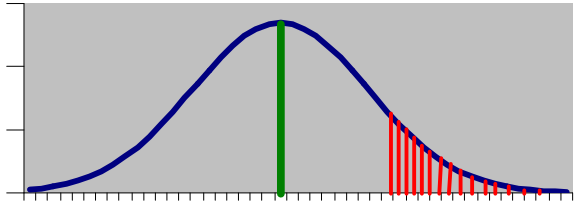
Biotechnologies at work: Clonal micropropagation

Hybrids

(E.oleifera x E.guineensis)

↓

Exploiting variability



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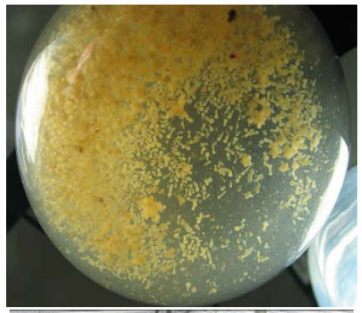
Cloning outstanding individual palms

23% OER and 30 t FFB/ha

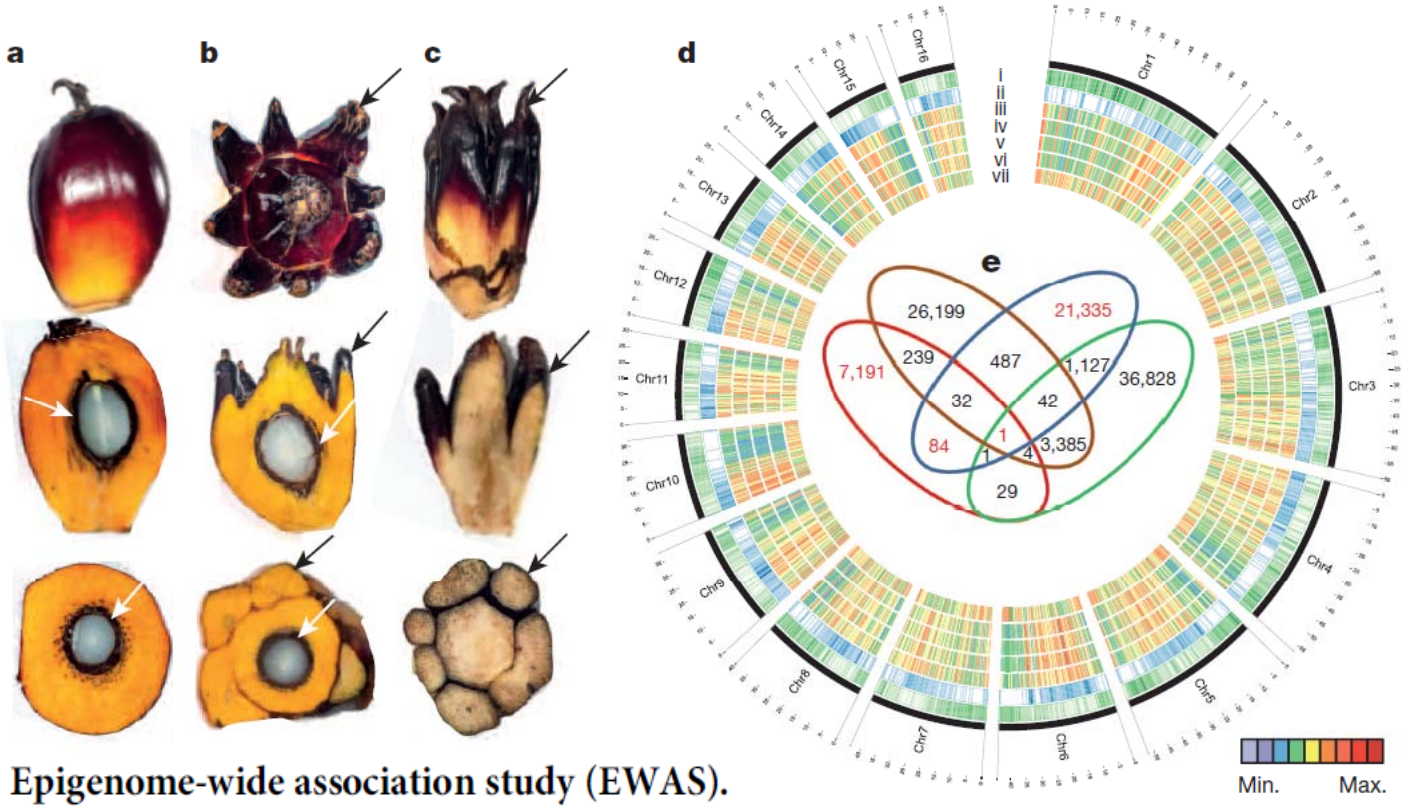
↓

Clonal planting material



PalmElit cirad

Biotechnologies at work: Epigenetics of flowering



Epigenome-wide association study (EWAS).

Loss of *Karma* transposon methylation underlies the mantled somaclonal variant of oil palm

Meilina Ong-Abdullah[1], Jared M. Ordway[2], Nan Jiang[2], Siew-Eng Ooi[1], Sau-Yee Kok[1], Norashikin Sarpan[1], Nuraziyan Azimi[1], Ahmad Tarmizi Hashim[1], Zamzuri Ishak[1], Samsul Kamal Rosli[1], Fadila Ahmad Malike[1], Nor Azwani Abu Bakar[1], Marhalil Marjuni[1], Norziha Abdullah[1], Zulkifli Yaakub[1], Mohd Din Amiruddin[1], Rajanaidu Nookiah[1], Rajinder Singh[1], Eng-Ti Leslie Low[1], Kuang-Lim Chan[1], Norazah Azizi[1], Steven W. Smith[2], Blaire Bacher[2], Muhammad A. Budiman[2], Andrew Van Brunt[2], Corey Wischmeyer[2], Melissa Beil[2], Michael Hogan[2]†, Nathan Lakey[2], Chin-Ching Lim[3], Xaviar Arulandoo[3], Choo-Kien Wong[4], Chin-Nee Choo[4], Wei-Chee Wong[4], Yen-Yen Kwan[5], Sharifah Shahrul Rabiah Syed Alwee[5], Ravigadevi Sambanthamurthi[1] & Robert A. Martienssen[6]

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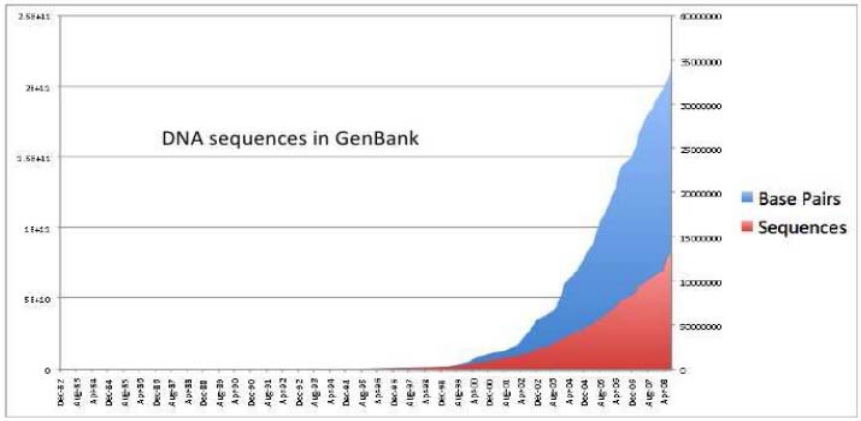
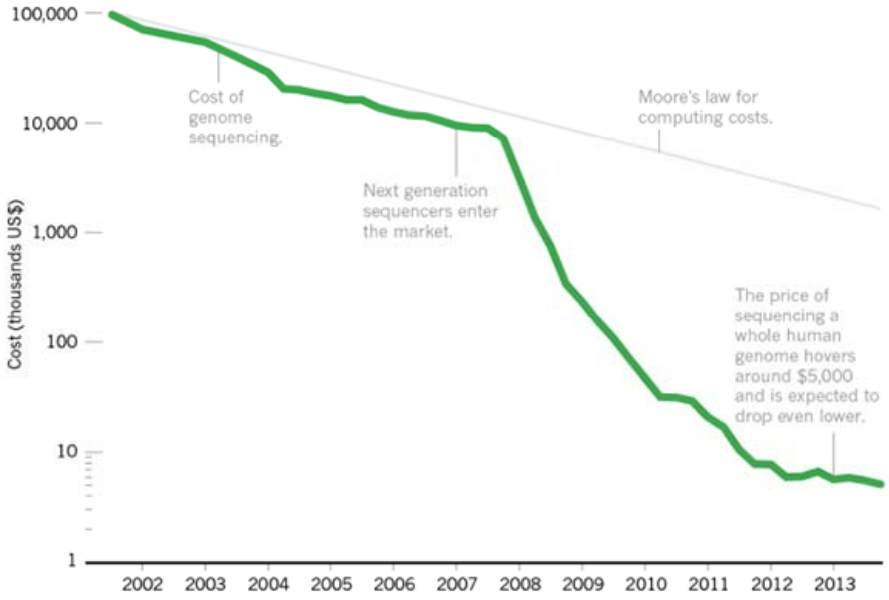
The *Next Generation Sequencing* Revolution



Doubling time = 18 months

Falling fast

In the first few years after the end of the Human Genome Project, the cost of genome sequencing roughly followed Moore's law, which predicts exponential declines in computing costs. After 2007, sequencing costs dropped precipitously.



Biotechnologies are working for sustainability

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- Environmental services
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- Greenhouse Gases mitigation

METAGENOMICS

Understanding life in soil and water

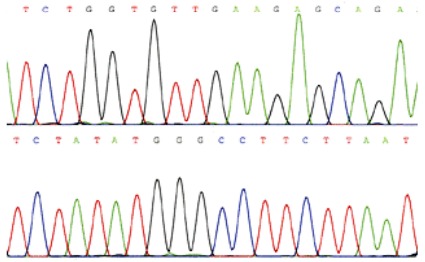
THE METAGENOMICS PROCESS

DETERMINE WHO IS THERE

(Sequence-based metagenomics)

- Identify organisms, genes and metabolic pathways
- Compare to other communities
- Compare treatments and cultural practices

Extract all DNA from microbial community in sampled environment



DNA sequencing

DETERMINE WHAT THEY ARE DOING

(Function-based metagenomics)

- Screen to identify functions of interest, such as nitrate reduction, or carbone fixation
- Find the genes that code to functions of interests

The *NGS* Revolution impacts oil palm research

- The vanishing gap between crop and model plant species **NOW**
- Whole Genome Sequence availble **NOW**
- Metagenomics of soil and water **NOW**
- Transcriptomics and gene discovery **NOW**
- Genomic selection **NOW**
- Epigenomics **NOW**

Muchas gracias por su amable atencion